

EXHIBIT 1

United States District Court
District of Minnesota

Kevin Khottavongsa
Plaintiff,

v.

City of Brooklyn Center, et al
Defendants.

No. 0:16-cv-01031-RHK-BRT

EXPERT REPORT OF MARK KROLL, PhD, FACC, FHRS, FIEEE, FAIMBE

I, Mark Kroll, being of legal age and under the penalties of perjury, state as follows:

1. I am a competent adult and have personal knowledge of the following facts, or believe them to be true based on information and belief. Facts about which I do not have personal knowledge are of the type reasonably relied upon by experts in this field and have probative value to me in rendering my opinions.
2. Attached hereto is a true and accurate copy of my expert report in this litigation.
3. The report summarizes my analysis and findings and includes a statement of my opinions. The report also includes data and other information considered by me in forming my opinions and sets out my qualifications (including my CV).
4. My opinions are expressed to a reasonable, or higher, degree of professional certainty.
5. I affirm under the penalties of perjury that the foregoing statements are true and correct.



Mark Kroll, PhD, FACC, FHRS

7 June 2017

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Brief Summary of Qualifications

I am a Biomedical scientist with a primary specialty in bioelectricity or the interaction of electricity and the body. My secondary biomedical specialty is biomechanics with a specific focus on the biomechanics of arrest-related-death (ARD).

The bioelectricity scientific work involves researching, lecturing, and publishing on electric shocks and their effects on the human body. It includes lectures throughout Europe, South America, and Asia (in over 30 countries) as well as at many of the major universities and medical centers of the United States (U.S.). Usually, the typical audience member is a cardiologist electrophysiologist or medical examiner. With 370 issued U. S. patents and numerous pending and international patents, I currently hold the most patents on electrical medical devices of anyone in the world. Over 1 million people have had devices with some of these patented features in their chest, monitoring every heartbeat. <http://bme.umn.edu/people/adjunct/kroll.html>

In my subspecialty of ARD biomechanics I published the first paper establishing the amount of weight required to crush the human chest.¹ I also published the first paper on fatal head injuries from skull fractures from CEW-induced falls.² Other ARD biomechanics papers include an indexed letter and a ResearchGate technical white paper on compression asphyxia.^{3,4}

Adjunct full professor of Biomedical Engineering at the University of Minnesota and the California Polytechnic University. In 2010 was awarded the Career Achievement Award by the Engineering in Medicine and Biology Society which is arguably the most prestigious award given internationally in Biomedical Engineering. <http://tc-therapeutic-systems.embs.org/whatsnew/index.html>

Believed to be the only individual to receive the high "Fellow" honor from both Cardiology and Biomedical societies. To wit:

1. 1997 Fellow, American College of Cardiology
2. 2009 Fellow, Heart Rhythm Society
3. 2011 Fellow, IEEE Engineering in Medicine and Biology Society
4. 2013 Fellow, American Institute for Medical and Biological Engineering

Author of over 200 abstracts, papers, and book chapters and also the co-editor of 4 books including the only 2 scientific books on the CEW:

1. TASER[®] Conducted Electrical Weapons: Physiology, Pathology and Law. Springer-Kluwer 2009.
2. Forensic Atlas of Conducted Electrical Weapons: Springer-Kluwer 2012

Directly relevant paper publications include over 60 papers, books, book chapters, and indexed letters on TASER CEWs as well as numerous scientific meeting abstracts.^{2,5-69} For more details please see curriculum vitae at:

<https://www.dropbox.com/sh/wju0hu6q3ca62xx/AAAlzTILbKbxu5m34AsMfCrYa?dl=0>

There have also been many presentations on CEWs to scientific and medical audiences. These include: 2007 AAFS (American Academy of Forensic Science) conference major presentation in San Antonio, Texas¹⁴ and the 2007 BEMS (Bio-electromagnetic Society) meeting Plenary Address in Kanazawa, Japan.¹²

1. Major invited lecture at the 2006 NAME (National Association of Medical Examiners) conference in San Antonio, Texas.⁷⁰
2. Advanced Death Investigation Course of St. Louis University (2007) as faculty lecturer to full audience.⁷¹
3. Faculty lecturer to full audience at Institute for the Prevention of In-Custody Death Conferences (2006 and 2007), Las Vegas, Nevada.
4. Chair of special session on TASER CEW at 2006 Cardiotim meeting in Nice, France.
5. Guest lecture to U.S. Military on CEW in 2006.
6. "Presenting Rhythm in Sudden Custodial Deaths After Use of TASER® Electronic Control Device," was presented at the 2008 scientific conference of the Heart Rhythm Society.⁷²
7. "Can Electrical-Conductive Weapons (TASER®) alter the functional integrity of pacemakers and defibrillators and cause rapid myocardial capture?" was presented at the 2008 scientific conference of the Heart Rhythm Society.¹⁹
8. "Weight-Adjusted Meta-Analysis Of Fibrillation Risk From TASER® Conducted Electrical Weapons" presented at the 2009 AAFS conference.²⁷
9. "Meta-Analysis Of Fibrillation Risk From TASER® Conducted Electrical Weapons as a Function of Body Mass" presented at the 2009 scientific conference of the Heart Rhythm Society.²⁸
10. Oral presentation at the 2014 NAME (National Association of Medical Examiners) conference in Portland, Oregon.
11. Pathophysiological Aspects of Electroshock Weapons. University of Salzburg Electroshock Weapon Symposium. Salzburg, Austria July 2015.
12. Real and Imagined Risk of Electrical Weapons. University of Salzburg Electroshock Weapon Symposium. Salzburg, Austria. Dec 2016.

In addition to the major addresses above, there have been lectures at the United States Department of Justice (2007), AAFS (2006), and BEMS (2006) regarding the TASER CEW.

I have shot TASER CEWs numerous times and have personally experienced an X26 CEW probe deployment discharge directly to the center of my chest. I have sat on the TASER corporate board since Jan 2003 and their scientific and medical advisory board since Aug 2004. Also sit on the International Electrotechnical Commission (Geneva, Switzerland) TC64 Committee that provides the scientific input to the international electrical safety standards.

Retained expert in over 140 cases involving a CEW. Courtroom testimony in USA, Australia, and Canada.

I also have significant research, publications, and testimony in the areas of resuscitation, arrest-related-death, and prone restraint.^{1,3,4,57-59,73-75}

Of particular relevance here, I am the lead author on the only scientific paper on the risks and mechanism of death from head injury with CEW-induced falls.²

Brief Narrative

In the evening of 16 January 2015, Mr. Sinthanouxay Khottavongsa was in a fight and suffered injuries to his facial bones and top of his skull. Officer Alan Salvosa, of the Brooklyn Park Police Department arrived later and used his department-issued TASER X26 electrical weapon to electronically control Mr. Khottavongsa as he refused to drop a large crowbar. Mr. Khottavongsa fell backward, hitting his head. He later rolled and partially sat up and was again electronically controlled whereupon he returned to his supine position with a low-impact roll from his seated position. Tragically, he later died.

Summary of Case Specific Opinions

1. The use of electronic control by Ofc. Salvosa represented the safest force option available to control Mr. Khottavongsa. Alternative force techniques triple (3x) the injury rate compared to electronic control.⁷⁶⁻⁸⁶
2. The roll from the partial seated position generated a mild contact with an estimated HIC₁₅ (15 ms Head Injury Criterion) of only 62.
3. There is no neurological damage expected from a contact with an HIC of only 62.
4. There was no expected cumulative effect from the head contact of the fall and the roll.

A Brief Primer on Benefits and Risks of Electronic Control

Electronic control benefits are well-established in the peer-reviewed literature and explain why these weapons are so widely adopted throughout the industrialized world (107 countries). Suspect injury rates are cut by $\sim 2/3$. In other words, the use of alternative force options tends to triple (3x) the injury rate compared to the CEW.⁷⁶⁻⁸⁶ The number of law enforcement firearms shootings prevented has been estimated at over 100,000 based on the 3 million field uses.^{23,87} In agencies using the CEW with minimal restrictions, the *fatal* officer shooting rate falls by $\sim 2/3$.⁸⁸

Table 1. Primary risks from probe-mode and drive-stun applications.

	Probe Mode	Drive-stun	Notes
Primary (Direct) Risks			
Electrocution	Theoretical possibility with probe directly over heart in subjects under 46 lbs. ³⁸ In general, the electrocution risk in adults is an urban legend. ^{52,66,89}	Essentially impossible. Even swine do not get VF (ventricular fibrillation) with a drive-stun. ⁹⁰⁻⁹³	Present CEWs satisfy all world electrical safety standards including those for the electric fence.
Loss of vision	Demonstrated with probes penetrating the eye. ^{43,94-99}	Unlikely. Has not been reported.	
Secondary (Indirect) Risks			
Head injury from uncontrolled fall.	Fatalities demonstrated. ¹⁰⁰ Non-fatal injuries demonstrated. ^{86,101}	Unlikely. Has not been reported in the literature.	
Fume ignition.	Fatalities demonstrated. ^{38,102,103}	Unlikely. Has not been reported. ¹⁰²	

The primary demonstrated and theoretical risks supported by the existing literature are outlined in Table 1. The most common (yet rare) contribution to fatality is a secondary injury from a head impact from an uncontrolled fall and there have been 16 deaths due to this.¹⁰⁰ This has not been reported with the drive-stun mode as there is no muscle lock-up. This rare cause of death is seen primarily in older individuals. The age of subjects with fatal traumatic brain injury from a standing or walking fall is 53.3 ± 9.4 years.

There have been 6 fatal cases of secondary injury fatalities in which flammable fumes were ignited possibly by an electrical spark from the CEW.^{38,102,103} This has not been reported with drive-stuns although that remains a very unlikely theoretical possibility.

The most misunderstood and exaggerated theoretical risk is that of electrocution. This is extremely unlikely as the output of existing CEWs satisfy all relevant world electrical safety standards including those for the ubiquitous electric fence.¹⁰⁴⁻¹⁰⁶ The primary driver of this myth appears to be the fundraising material of Amnesty International that lists Arrest-Related Deaths (ARDs) with electronic control along with the innuendo that the electronic control somehow caused the death. Notably, they have never attempted to explain how a CEW — that satisfies all electrical safety standards — could ever electrocute anyone.

Swine are 3 times as sensitive to electrical current as humans.¹⁰⁷ The largest swine electrocuted by an X26 CEW was that of Valentino and it weighed 36 kg (79 lbs).¹⁰⁸ Nanthakumar also electrocuted a *single* 50 kg swine but he used a drug trick which made the swine's weight equivalent to ~ 30 kg.¹⁰⁹ Hence the largest swine ever directly electrocuted by a normal CEW output weighed only 36 kg.

The levels of dangerous electrical current scale with body mass just like any drug dosage. Since Walcott has shown that swine are 3 times as sensitive to electrical current (as humans) we can translate the Valentino 36 kg pig to a 12 kg (26 lb) human.¹⁰⁷ This calculation uses a direct proportion relationship of dangerous current levels to the body mass. Some authorities have published that the danger level scales with the square root of body mass.¹¹⁰ With such a relationship the Valentino pig is equivalent to a larger 21 kg (46 lb) human. If we take the more conservative calculation, it is clear that the best evidence suggests that the risk of CEW electrocution is limited to humans with a body mass under 46 lbs.

Most authorities agree that electrocution is a theoretical possibility with an extremely thin individual and a fully penetrating CEW probe directly over the heart.^{27,39,111} The debate centers on whether or not this has been yet demonstrated in an actual case.^{52,89,112}

Details of the Opinion

The Use Of Electronic Control Represented The Safest Force Option

The 2008 Eastman study found that 5.4% of CEW uses “clearly prevented the use of lethal force by police.”⁸⁷ The largest epidemiological study was the 2009 MacDonald study of 24,380 uses of force.⁷⁸ This US DOJ-sponsored study found that CEW usage dramatically reduced both suspect and officer injury compared to alternative force options.

Other of the numerous epidemiological studies include the papers of Taylor (13,983 subjects), Mesloh (n = 4303), Mumola (n = 2686), Smith (n = 1645), Butler (n = 562), and White (n = 243).^{85,113-117} These studies covered a total of 48,228 subjects and none of these studies had any involvement with the TASER company.

Mesloh studied CEW usage in comparison to many other control options.⁸⁵

- Gentle hold
- Handcuff
- Leg restraints
- Pepper spray
- Compliance holds
- Takedown
- Empty hand strike
- FN303/Pepperball
- Impact weapon
- Canine

These studies consistently show an injury rate reduction of about 2/3 with the use of the TASER CEW.

The Head Impact Criterion Score

The HIC₁₅ (15 ms Head Injury Criterion Score) is the accepted method for calculating the risk of head injury for an impact.¹¹⁸⁻¹²³ This will be abbreviated as “HIC” going forward. The HIC has proven accurate and useful and thus it is written into governmental regulations on motor vehicle safety, helmets, and even playground surfaces. The HIC depends on the impacted surface, the impacted part of the head, the body position at the impact, and the velocity of the impact.

Figure 1 depicts the risk of *skull fracture* as a function of HIC as determined from actual accident data by Marjoux.¹²¹

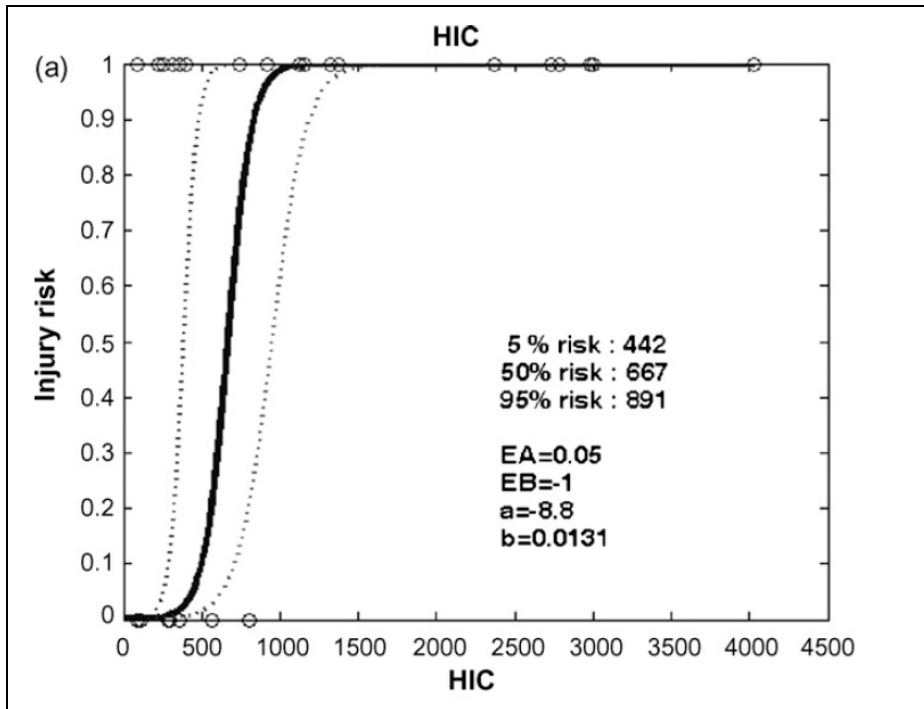


Figure 1. Risk of skull fracture as a function of HIC.

Figure 2 depicts the risk of *severe neurological injury* as a function of HIC as determined from accident data by Marjoux.¹²¹ Figure 3 depicts the risk of subdural hematoma as a function of HIC as determined from actual accident data by Marjoux.¹²¹

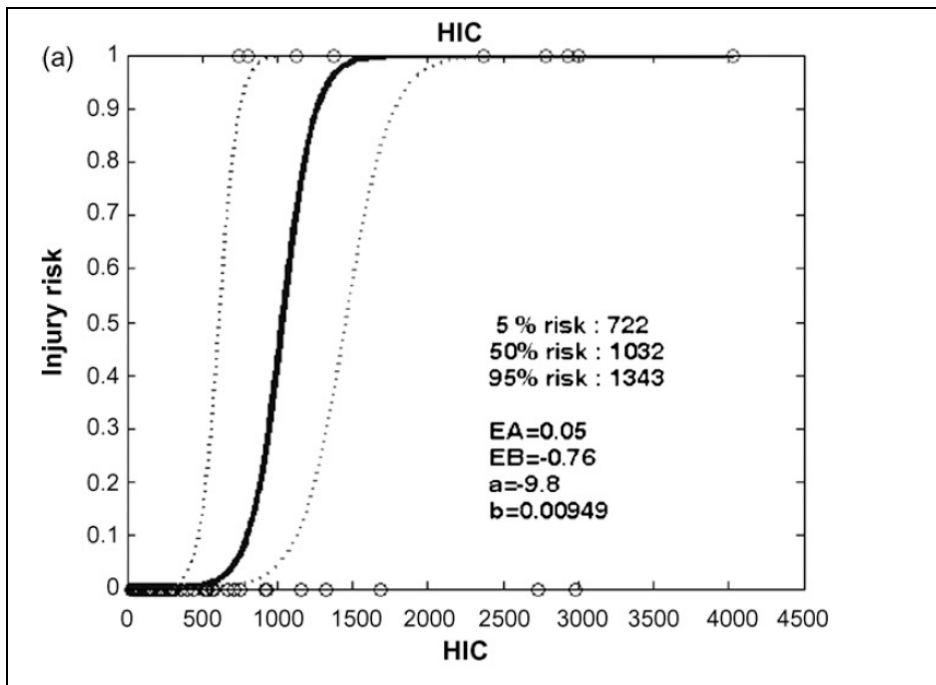


Figure 2. Risk of severe neurological injury as a function of HIC.

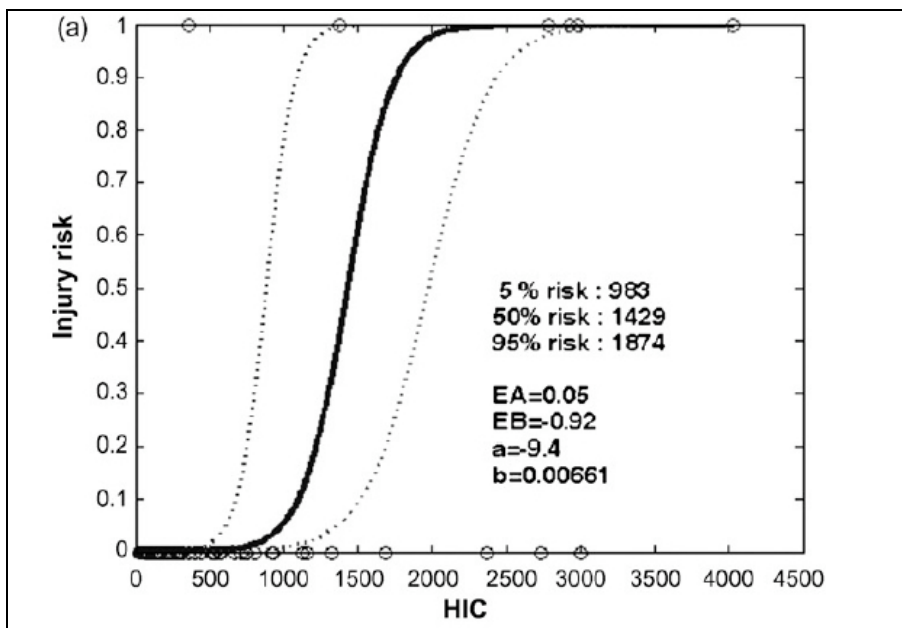


Figure 3. Risk of subdural hematoma as a function of HIC.

As seen above, an HIC > 1000 is typically required for a serious head injury. Even a moderate head injury typically requires an HIC > 500 as seen in Figure 4.

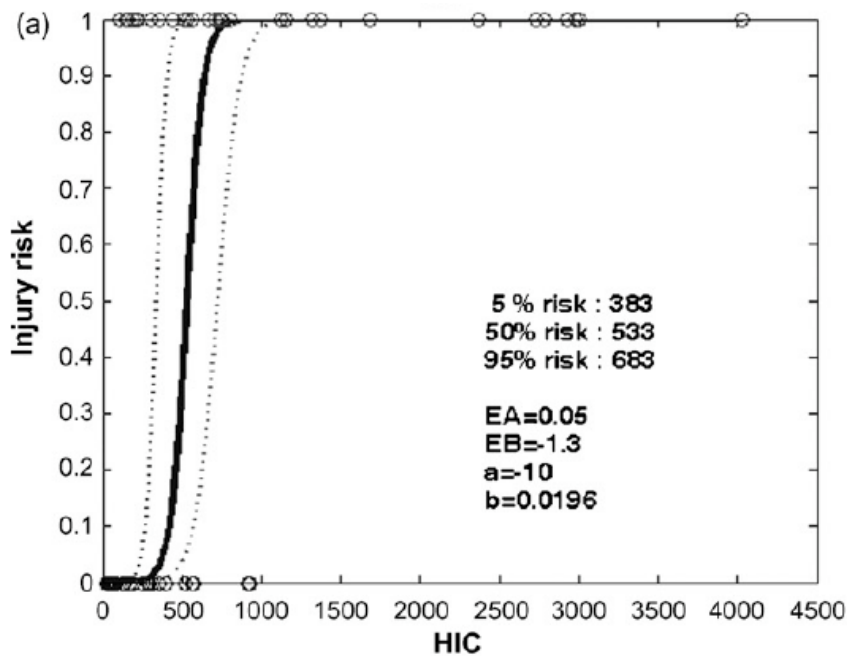


Figure 4. Risk of moderate neurological injury as a function of HIC.

The Roll

After the fall, Mr. Khottavongsa began to roll up on his right elbow. After warnings were given, electronic control was used on him. Mr. Khottavongsa then rolled back to his right shoulder, back, and then somewhat to his left shoulder. This is shown in Figure 5 taken from the Deering dash camera.



Figure 5. Khottavongsa roll.

The head contact occurs at frame 9 of Figure 5. There is 0.133 s elapsed (from frame 7) and I estimate the head height at frame 7 to be 25 cm (10 inches). This gives an average velocity of 1.9 m/s. The HIC scores for low-velocity contact are shown in Figure 6.

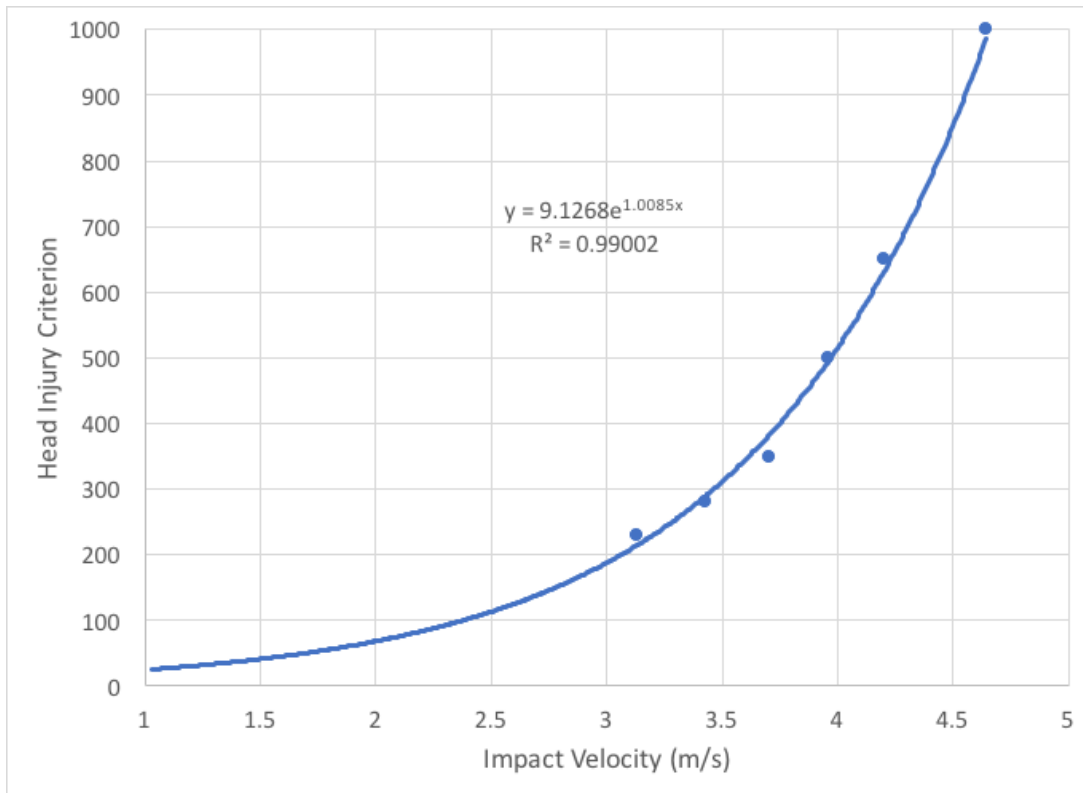


Figure 6. HIC scores for low-velocity contact.

The HIC for a 1.9 m/s contact is 62. As shown in the previous plots, there is a 0 risk of neurological injury or skull fracture. This might cause a mild goose bump.

Effect of the Fall

Fixed-hip backward falls can have HIC scores of ~4000.¹¹⁸

Fixed-hip backward falls can, indeed, be fatal and we have published on this in regards to electronic control.² We were aware, earlier, of the case of Mr. Khottavongsa and requested his autopsy report multiple times only to be politely told that it was confidential under Minnesota law. The public death certificate listed the cause of death as “blunt force craniocerebral trauma” and his death was ruled a homicide. Media reports mentioned that the fall was caused by a CEW exposure and thus we included this case in our study.

Had we been provided the autopsy report we would not have included Mr. Khottavongsa in our study since his skull fractures were all in the front ½ of the skull.

Expert Report of Robert Beatty, MD

I read the expert report of Dr. Beatty and wish to comment on those parts that may not comport with the peer-reviewed scientific literature.

Dr. Beatty attempts to conflate the head contact of the roll with the impact of the fall. He opines that the roll contact (with HIC = 62) was “cumulative” with the impact of the fall. Since the impact of a fixed-hip backward fall has a typical head injury criterion of about 4000 (~70 times that of the roll), this is extremely unlikely.¹¹⁸ He also does not cite to any scientific literature to support his opinion regarding the cumulative effects of multiple head contacts.

There is no evidence that Dr. Beatty ever calculated the HIC of either the fall or the later roll. Rather, he simply refers to both as falls. He correctly describes the effect of the *fall* as “landing forcefully on the back of his head on the concrete.” However, Dr. Beatty refers to the head contact of the *roll* as “... a second forceful blow to the back of his head.”

Dr. Beatty opined:

The blow from the second tase significantly contributed to an already bleeding process. The normal attempt of his body to stop the bleeding was interrupted from the second blow to the head from the second tase. The second blow, in combination with the first blow, more likely than not resulted in an irreversible brain hemorrhage not amenable to surgery, as well as caused Mr. Khottavongsa additional pain. Thus, it is my opinion that these two head injuries were cumulative and ultimately led to his death.

Dr. Beatty cites to no peer-reviewed literature to support his conjecture that a 62 HIC contact can contribute to a bleeding process. Dr. Beatty does not identify the “normal attempt” of the body to stop intracranial bleeding. Dr. Beatty cites to no peer-reviewed literature to support his conjecture that a 62 HIC contact can interfere with this “normal attempt” process. Dr. Beatty’s speculation, that the initial fall and roll were cumulative, is not supported by the HIC of the roll which was about 1.5% of the total HIC of the fall and the roll.

Case Specific Materials Reviewed or Considered

Hennepin County Investigation File

- a. ICR – Hennepin County Incident Reports
- b. Medical Examiner Reports
- c. Brooklyn Center Officer Statements taken by Hennepin County
- d. Laboratory Analysis Request
- e. Officer Salvosa Alcohol and Drug Blood Draw Consent/Results/Supplemental Report
- f. Coin Laundry Search Warrant
- g. Clothing of Sinthanoux Khottavangsa Search Warrant
- h. Chain of Custody Evidence Form and Property Receipt
- i. HCME Evidence Receipt/HCSO Crime Lab Request for Lab Examination
- j. CAD Report
- k. Taser Evidence Sync
- l. HCSO Laboratory Examination Reports
- m. Letter of Representation for Sinthanouxay Khottavongsa

Coleman Deposition Transcript and Exhibits

Deering Deposition Transcript and Exhibits

Gannon Deposition Transcript and Exhibits

Jackson Deposition Transcript

Nordby Deposition Transcript and Exhibits

Salvosa Deposition Transcript and Exhibits

Turner Deposition Transcript and Exhibits

Whittenburg Deposition Transcript and Exhibits

Cruz-Martinez Deposition Transcript

Elmi Deposition Transcript

Galarza Deposition Transcript

Hong Deposition Transcript

Khottavongsa Deposition Transcript

Sarin Deposition Transcript

Som Deposition Transcript

Autopsy Report

Salvosa Report

Coleman Supplemental Report

Death Certificate

Declaration of Sarin

Deering Supplemental Report

Nordby Supplemental Report

Turner Supplemental Report

Whittenburg Supplemental Report

Interview recordings

North Memorial Medical Records

Report of Resistance

Expert report of Dr. Beatty

Expert Report of Dr. Samadani

Expert report of Dr. Beatty

Brooklyn Center Squad Video Officer Salvosa

Brooklyn Center Squad Video Officer Turner

Brooklyn Center Squad Video Officer Deering

Exhibits

The exhibits or list of references used as a summary of or support for the information and opinions in this report specifically include each illustration, graphic, chart, and video in this report, referenced in this report, or included in any of the references to this report, as well as any documents, or portions thereof, referenced or cited, or any compilation of documents, are to be considered exhibits to this report and may be utilized as exhibits at deposition and/or trial. These exhibits specifically include, but are not limited to: any document, information, illustration, Microsoft® PowerPoint®, lesson plan, drawing, graphic, video, compilation, etc., that is on, or included in, any of the TASER International, Inc. (TASER) training CDs/DVDs (versions 1 through the current release – which is presently version 19), TASER CEW Research Index, TASER Fact Sheets (TFSs), as well as the TASER* Research Compendium, the Arrest-Related Death (ARD) Research Index and Compendium, TASER ECD Field Data and Risk Benefit PowerPoint presentations and Analyses, Volunteer Exposure Reports, spreadsheets, and analyses, Field Use Reports, data, summaries, and appendices, the TASER website (including updates and additions), the www.ecdlaw.info and www.ipicd.com websites, etc. Exhibits also include an ADVANCED TASER M26™ (M26) ECD, TASER X26™ ECD (X26), TASER X2™ ECD, TASER X3™ ECD, fully kitted M26 ECD, fully kitted X26 ECD, fully kitted X2 ECD, fully kitted X3 ECD, TASER cartridges, TASER cartridge wire, TASER probes, a Van de Graff generator, 8 AA cells, 2 Duracell® CR123 cells, an X26 Digital Power Magazine (DPM), an X26 ECD eXtended Digital Power Magazine (XDPM), stacks of 10,000, 25,000, 50,000, and 100,000 sheets of copy-type paper, vehicle battery jumper cables, 110 V alternating current (AC) electrical cords/cables, ground fault circuit interrupter (GFCI), a can of Pepsi® or other soft drink, an empty soda can, a Nikon® F6 camera, and other exhibits and demonstrative aids.

Electric fence energizers of various brands

Electroconvulsive therapy (ECT) generator

Transcutaneous electronic nerve stimulators (TENS) of various brands

Sound recordings of CEWs played at both normal and slow speed

* AIR TASER, M26, X26, X2, and X3 are trademarks of TASER International, Inc. TASER® and ADVANCED TASER® are registered trademarks of TASER International, Inc.

Detailed Background:

Drive-Stun Mode: Skin Rub vs. Injection

As opposed to the typical probe-mode, the CEW may be used in a “drive-stun” mode by pushing the front of the weapon into the skin to function as a higher charge stun gun. With the fixed electrodes only 4 cm (centimeters) or 1.6 inches apart — and the lack of skin penetration — the current flow is primarily through the dermis and fat layer between the electrodes and there is no significant penetration beyond the subdermal (or subcutaneous) fat layer. See Figure 7. Since there is insufficient depth of current flow to capture muscles, the drive-stun mode serves only as a compliance technique.

To make an analogy to medicine, drive-stun is like rubbing an ointment on the skin compared to the probe mode, which is like an injection. They have significantly different effects.

As mentioned above, small swine (30 kg or 65 pounds) can occasionally be put into VF when fully-embedded CEW *probes* are nearly touching the heart.^{124,125} *However, it is not possible to fibrillate even small swine with a transcutaneous CEW drive-stun application.*⁹⁰⁻⁹³ The electrical current simply does not penetrate deeply enough to affect any human muscles or organs. In fact, with a CEW drive-stun application directly over the human phrenic nerves (the nerves that control breathing) there is no effect.¹²⁶

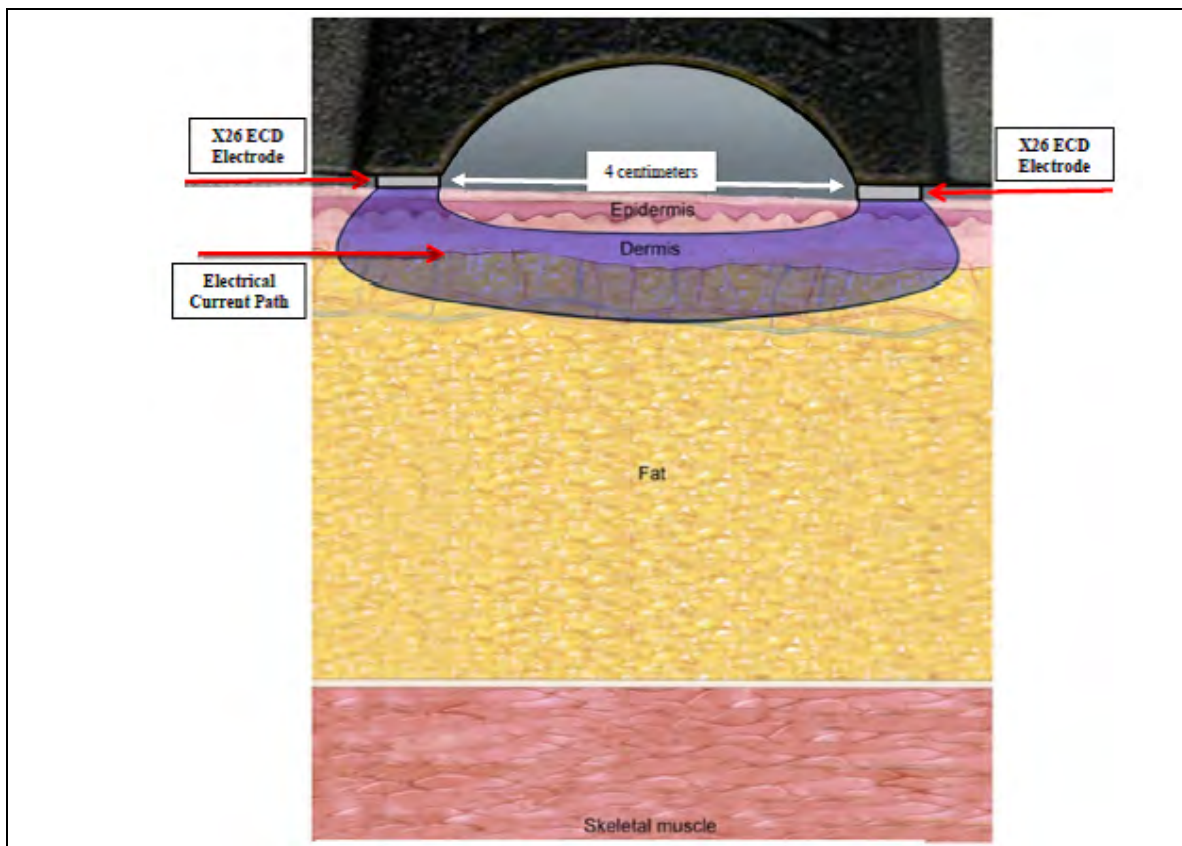


Figure 7. The majority of the drive-stun current is confined to the fat and dermis layer.

The American Academy of Emergency Medicine (AAEM) has the following guideline on drive-stun applications:¹²⁷

For patients who have undergone drive stun or touch stun ECD exposure, medical screening should focus on local skin effects at the exposure site, which may include local skin irritation or minor contact burns. This recommendation is based on a literature review in which thousands of volunteers and individuals in police custody have had drive stun ECDs used with no untoward effects beyond local skin effects.

The National Institute of Justice, 5-year study of CEWs, found:¹²⁸

Risk of ventricular dysrhythmias is exceedingly low in the drive-stun mode of CEDs because the density of the current in the tissue is much lower in this mode.

The Federal Court of Appeals for the 9th Circuit [*Brooks v Seattle*], and others, have concluded:

The [TASER CEW]'s use in "touch" or "drive-stun" ... involves touching the [TASER CEW] to the body and causes temporary, localized pain only. ... this usage was considered a Level 1 tactic, akin to "pain compliance applied through the use of distraction, counter-joint holds, hair control holds, [and pepper spray]" and used to control passively or actively resisting suspects.

CEW drive-stun applications have no clinically significant physiological or pathological effects.

CEW Comparison to TENS Units

TASER CEWs deliver less current than some models of TENS (Transcutaneous Electronic Nerve Stimulator) units. For example, the popular EMPI[®] Select[™] unit delivers up to 4.5 mA (milliamperes) of average current which is more than the 2.1 mA of the TASER X26 CEW or the 1.2 mA of the X2. It is very popular in Europe to use TENS units for treating angina with the electrodes placed across the cardiac silhouette.¹²⁹⁻¹³¹ No deaths or injuries have been reported.

The X26 and X2 CEW delivers less average current than some transcutaneous nerve stimulators, which are often used directly across the heart without problems.

Misunderstanding the Trigger-pull Download

A common forensic analysis error is to assume that the "TASER" download represents current delivery to the subject. It does not. It represents only an outer bound on the seconds of current delivery. The total time given by the download is typically 2-3 times what the actual total duration of current delivery was. This is theoretically harmless as the total duration of current is essentially irrelevant to diagnostics since electricity does not build up like poison. Thus, the most exaggerated figures are the least relevant.

A TASER download printout showing trigger pull times with a total of, say, 100 seconds provides the following information:

1. The times of the trigger pulls (after clock-drift correction).

2. The number of seconds of current delivery is 0-100. I.e. somewhere between 0 and 100 seconds.

As an example, in the tragic death of the methamphetamine addict, Robert Heston, (who attacked his father and father's home) there were a total of 206 seconds of trigger-pulls on the 5 M26™ CEWs and 6 deployed cartridges used to control him.¹³² A careful analysis found that the actual duration of current delivery was 5-9 seconds. Here the exaggeration was at least 20:1. In a non-USA case (unnamed here due to confidentiality restrictions) there was a total of 154 seconds of trigger-pull duration from 28 trigger pulls. Each CEW had a camera attached and thus the actual duration of current delivery could be determined from an audio analysis.⁵⁹ There was a total of only 20 seconds of current delivered.

A US Federal Court ruling included a statement that CEW trigger pull records do not equate to delivered current, quoting the law enforcement defense expert:¹³³

The TASER log shows only device activation; it does not represent that a shock was actually delivered to a body nor does it distinguish between probe deployment and drive stun.

Causes of Current Delivery Exaggeration:

1. Broken wires or dislodged probes
2. Rounding up to the next second
3. Muzzle contact canting with drive-stuns
4. Inadvertent trigger pulls

Broken Wires or Dislodged Probes

A major reason for multiple or prolonged trigger pulls is that the fragile wires are broken early on in the encounter and the officer continues to pull the trigger, hoping for a response.

The tiny wires (36 gauge, 127 microns in diameter) are about the diameter of some human hair and are usually quickly broken during any struggle and are typically broken when a subject turn and falls. The tensile strength, of the wires, is weaker (less than 1 kg) than the weakest fishing line (2 kg or 4 lbs breaking test) and are thus very easily snapped. In fact, in some instances prisoners now teach other inmates that they should roll over if they receive a CEW discharge, in order to break the wires.

Rounding Up to the Next Second

The reported trigger-pull durations, in the TASER download reports, are rounded up from the first 1/100 of a second. I.e. if the actual duration was 2.01 seconds then it is reported as 3 seconds. Thus the best estimate of the actual trigger pull is ½ second less than what is reported. Automatic duration trigger pulls of 5 seconds are, in fact, 5.00 seconds and thus there is less risk of an interpretation error there. This is irrelevant with the Trilogy logs which give trigger pull and arc-switch durations to the nearest 0.1 second.

Muzzle Contact Canting with Drive-stuns

As seen in Figure 8, a drive-stun application requires that the CEW muzzle be kept nearly perpendicular to the body surface. This can be difficult to do with a moving subject. The

typical subject will reflexively pull or roll away from the shock. On average, a good contact is only made about 30% of the time. If the muzzle is canted up to 20° away from perpendicular, then an arcing connection can still be made. The typical correction is to subtract 70% from the download times.

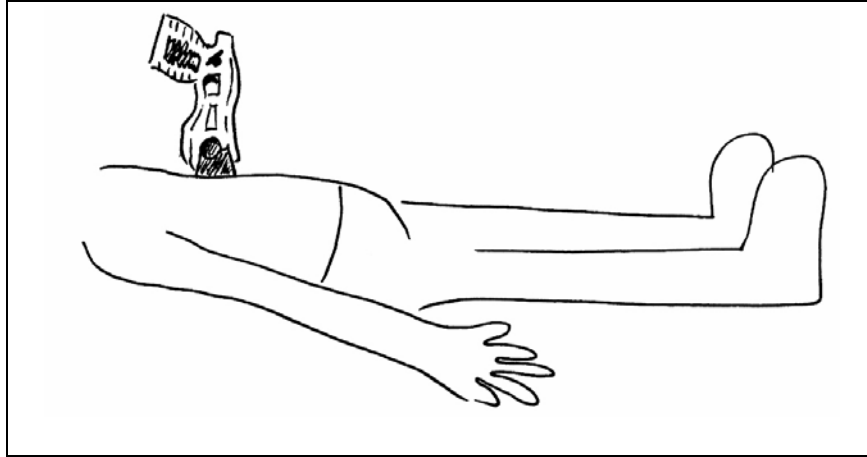


Figure 8. The drive-stun requires that the CEW muzzle be kept nearly perpendicular.

Inadvertent Trigger Pulls

Background:

The inadvertent trigger pull (ITP) has been well studied for firearms discharges.^{134,135} According to Heim there appear to be 3 primary causes:¹³⁴

1. sudden loss of balance;
2. contractions in the hand holding the weapon while other limbs are in use, for example during a struggle with a suspect;
3. startle reaction.

Common to every incident, in addition to the weapon being held in a hand, is that all limbs appear to be involved in the resulting sudden movement.¹³⁴ Recent work by the Lewinski group found no cases of firearm ITPs involving startle.¹³⁶ We have also not seen situations where a startle reaction led to a CEW ITP and thus we will focus on #1 and #2 above. Another potential cause is the *fist* reflex which is natural from birth and can be reinforced by training with closed-hand strikes; this can occur in a high stress confrontational situation.^{137,138} The fist reflex may not apply to CEW ITPs and will not be discussed further here.

Physiology:

It has been recognized for over 100 years that muscle contractions in any limb can lead to increased activity in other limbs.¹³⁹ This has generally been referred to as *motor overflow* or *overflow activity*.^{140,141} This is especially seen in opposite (contralateral) limbs where the phenomenon is referred to as *mirror movement*.¹⁴²⁻¹⁴⁵

When we contract a *single* hand firmly we also *invariably* contract the opposite hand somewhat.¹⁴⁶ Typical male grip strength is 130 ± 16 pounds where 25- 42% is exerted by the index finger.¹⁴⁷ Overflow activity can reach a maximum of 25% of the maximum

voluntary force of the individual limb.¹⁴⁸ Thus, forces of up to 14 pounds (= 25% • 42% • 130 lbs.) can be involuntarily exerted by the index finger.¹³⁴ This is sufficient to overcome the trigger pull (8-12 lbs.) for the 1st round of an uncocked pistol. Even when warned to keep their fingers off of the trigger — and knowing that they were being studied — 21% of officers contacted the trigger for > 1 second in stress simulations.¹³⁴ When studied with their index finger already on the trigger, 28% (=7/25) of volunteers gave involuntary trigger pulls of > 14 lbs. when they either pulled with their opposite arm or lost their balance.¹³⁴

The combination of involuntary muscle contraction activity and a finger on the trigger (which was either unconsciously pre-positioned or moved with the involuntary activity) is responsible for many inadvertent firearm discharges by law enforcement officers.^{135,136,149}

Electrical Weapons:

With the conducted electrical weapon (CEW), the incidence of ITPs is far greater — than with firearms — for 2 primary reasons:

1. The trigger pull is far less at only 2 lbs. for the popular X26 (X26E) and 3 lbs for the X2. The trigger is thus 3-6 times more sensitive than that of an uncocked pistol.
2. Officers commonly hold the CEW in their dominant hand and try to assist with subject control or lifting with the other hand. They would never do this with a firearm as it is forbidden by weapon retention training.

We have investigated many incidents in which the *majority* of trigger pulls appear to be ITPs. In the typical case the officer is maintaining his grip on the weapon while trying to restrain the subject with the free hand and possibly also the CEW-constrained hand. This can also occur while holstering the weapon if the opposite hand is being engaged in the struggle. Thus, during a physical struggle with the CEW in an officer's hand, most of the CEW discharges tend to be mirror movement ITPs which then run the full standard default 5 seconds or until the officer realizes what is happening (from the arcing sound) and turns the weapon OFF (safety ON). In many cases, the arcing sound is not noticed because of the yelling or the focus on a struggle.

Ironically, the situation is both far worse but also far better for the CEW compared to the firearm. While a CEW operator will have far more ITPs, the results are almost always harmless compared to the often-fatal consequences of a firearm ITP. Most of the ITPs occur with drive-stuns which are well established as having no deleterious effects outside of short-term minor contact burns.^{58,68,150} Moreover, the inadvertent drive-stun trigger pull is almost always with the weapon far away from the subject as the officer's opposite hand is the one in contact with the subject. For the minority of cases that began as a probe-mode deployment, the connection has usually been broken by the ground struggle. If a full probe connection was still existing, then there would be far less need for manual control and hence a low likelihood of an ITP.

Basic Background:

A. *The Electrophobia Myth*

Many people, both lay and professional, have an illogical emotional fear of electricity, *electrophobia*. From an early age in life it is drilled into young children that 110 V (volt) electrical outlets cause death. Thus, most people have deeply absorbed the urban myths that voltage itself is dangerous and 110 V causes death. While this is scientifically incorrect most people, including most media, hold these myths to be undeniable truths.

Some people subscribe to a myth that since the human body is 97% water and since water transmits electricity that electricity delivered anywhere on the body is carried by the water to the heart and thus causes electrocution. This too is scientifically silly for many reasons. Life itself could not exist without electricity. Trying to say that all electricity is dangerous is equivalent to saying that all balls are dangerous. There are marked differences in the effects of being struck a ping-pong ball, baseball, bowling ball, and wrecking ball. Getting hit with a ping-pong ball is not equivalent to getting hit by a wrecking ball. In this analogy the electrical impact from a CEW is approximately equivalent to a tennis ball while a 110 V wall outlet would be a bowling ball and a high-power transmission line or lightning strike would be a wrecking ball.

B. *CEW Probe Mode*

In probe mode, the TASER handheld CEW uses compressed nitrogen to fire 2 small probes at typical distances of up to 7.7 m (meters) or 25 feet.^{117,151} (Other TASER cartridge models can reach a distance of 11 m or 35 feet.) When the CEW trigger is pulled, the high voltage first serves to open the nitrogen cartridges to release the nitrogen to propel the probes as directed. These probes themselves are designed to pierce or become lodged in most light clothing (which is usually overcome by the 50,000 V-arcing capability). The sharp portion of the probe is typically 9-13 mm (millimeters) long and will typically penetrate the epidermis and dermis to a depth of ~6 mm for a good electrical connection.

Even as a strong static electrical shock will temporarily incapacitate someone, a series of 19 very short duration shocks per second can cause temporary muscle incapacitation. The ultra-short duration electrical pulses applied by TASER CEWs are intended to stimulate Type A- α motor neurons, which are the nerves that control skeletal muscle contraction, but without a high-risk of stimulating cardiac muscle. This typically leads to a loss of regional muscle control and a fall to the ground to end a violent confrontation or suicide attempt.

Small swine of 30 kilograms (65 pounds) can occasionally, but rarely, be put into VF when the CEW probes are put within a few mm of the heart.¹⁰⁸ One study used a custom long plunging probe to deliver the CEW current almost directly (within 6 mm or ¼ inch) to the heart of a pig in order to induce VF.¹⁵² Pigs are extremely sensitive to electrical currents due to their hearts being literally wired “outside-in” compared to a human’s (being wired “inside-out”).¹⁵³⁻¹⁵⁸ The swine heart needs 2/3 less current to go to VF (ventricular fibrillation) comparison to the human heart from external stimulation. I.e. the swine is 3 times as sensitive to electrocution as is the human.⁶³ There are numerous problems with

the swine model that significantly exaggerate the electrocution risk.⁵⁵ This CEW-electrocution effect is also confined to *small* swine.²⁷ In stark contrast, human studies consistently show no demonstrated risk of VF with a CEW application.¹⁵⁹⁻¹⁶⁷

This is clearly the consensus of the scientific and medical community as shown by various position papers. For example: the June 2009 American Medical Association White (Position) Paper concluded:¹⁶⁸

Furthermore, no evidence of dysrhythmia or myocardial ischemia is apparent, even when the bars are positioned on the thorax and cardiac apex.

On May 24, 2011, the National Institute of Justice, after a 5-year study, concluded:¹²⁸

Current research does not support a substantially increased risk of cardiac arrhythmia in field situations, even if the CED darts strike the front of the chest. There is currently no medical evidence that CEDs pose a significant risk for induced cardiac dysrhythmia in humans when deployed reasonably.

Finally, in June 2012, Bozeman stated:¹⁶⁹

The risk of such dysrhythmias, even in the presence of a transcatheter CEW discharge, is low, and suggest that policies restricting anterior thoracic discharges of CEWs based on cardiac safety concerns are unnecessary.

No danger or harm has been associated with the CEW probe-mode application, in human studies.

C. CEW Comparison to the Electric Fence

It is helpful to discuss the most common and longest existing electronic control device — which controls humans and other mammals by giving short painful electrical stimuli — namely the electric fence.

The IEC (International Electrotechnical Commission), the AU/NZS (Australian/New Zealand Standards), European Norm (EN), British Standards, and UL (Underwriters Laboratories) have long had standards for electric fences.^{170,171} These are the Particular Requirements for Electric Fence Energizers. IEC 60335-2-76, edn 2.1, AU/NZS 60479.1:2010, and the UL Standard for Electric-Fence Controllers in: Laboratories U, ed. UL 69. Independent testing has verified that the TASER X26 CEW satisfies both the IEC, AU/NZS, and UL electric fence standards.¹⁰⁴



Figure 9. The Stafix M63R electric fence energizer.

The X26 CEW satisfies the electric fence standards by a very wide margin.¹⁰⁴ Another comparison can be made between the outputs of the TASER X26 CEW and the Stafix electric fence energizer shown in Figure 9 which delivers 7 watts with a peak current of 17.2 A. Most electric fence energizers deliver higher charges and peak currents than do the TASER CEWs as seen in Figure 10.

Electric fences normally operate on a pulse rate of <1 PPS (pulse per second). This is because they are primarily designed to stop livestock walking slowly toward them. Obviously, this slow pulse rate is insufficient to quickly stop a resisting suspect as they can move too far in 1 second. This is why the TASER CEWs operate at a rate at 18-19 PPS. However, the electric fence standards do allow operations at higher pulse rates for a period of up to 3 minutes and have safety standards for those higher pulse rates. (Note that this 3-minute time limit is significantly higher than the total CEW application times alleged in this case.)

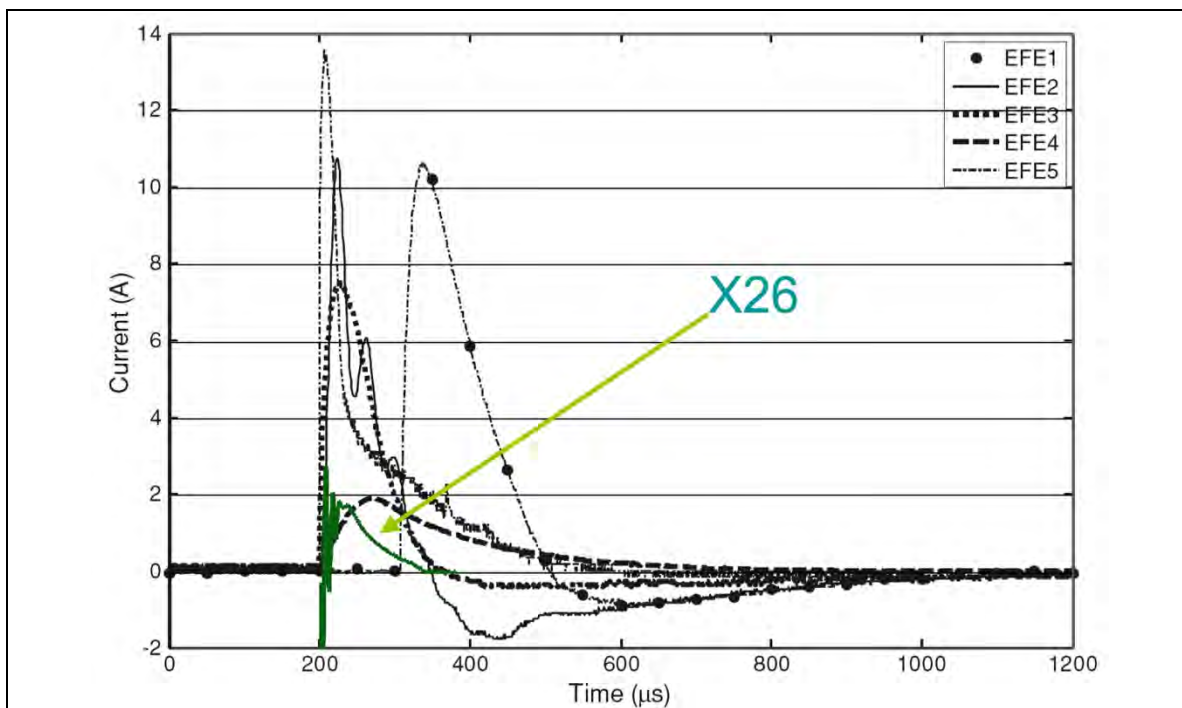


Figure 10. The CEW pulse delivers less current and charge than many electric fence units.

The conservative IEC standard allows up to 2.5 watts for an electric fence and all present TASER CEWs deliver less than 2 watts. The UL high-rate limits are found in section in 23.2.4 of the UL standard 69.¹⁷¹ It gives a pulse current limit of:

$$I = 20 \cdot D^{-0.7} / \sqrt{f}$$

Which is more easily understood in terms of a power limit as shown in Figure 11.

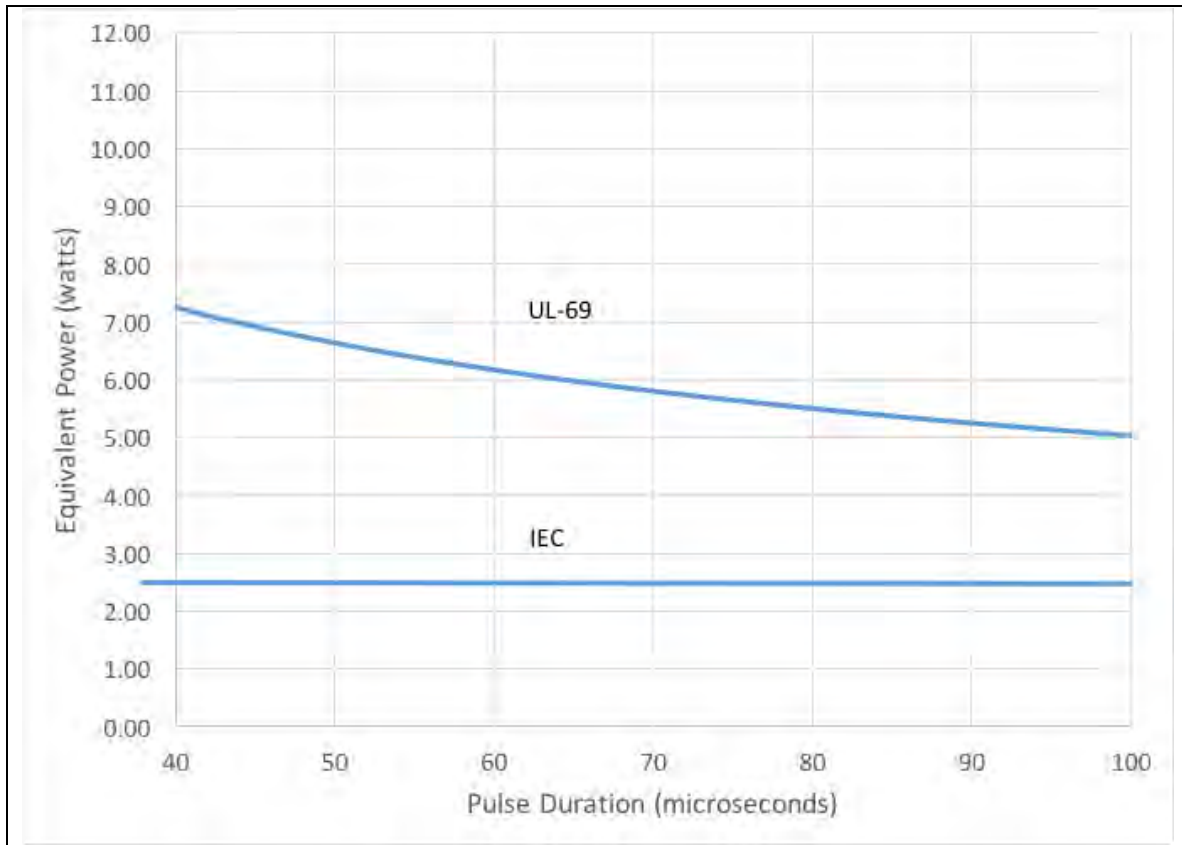


Figure 11. UL 69 and IEC 60335 electric fence equivalent power safety limit.

This limit is shown in Figure 11 which allows 5 watts for the wider-pulse X26 and 6 watts for the narrow-pulse X2. The electric fence standards have evolved from almost 100 years of experience with documented fatalities from earlier high-powered devices. The UL carefully collected data on these units to find out what was a safe limit. The typical accidental exposure to an electric fence is based on someone walking into it and thus is a frontal exposure. Depending upon the relative heights of the fence and the individual this exposure could be anywhere from the face to the thighs and could include skin penetration from barbs on barbed wire. These limits are very stringent and now fatalities from electric fences are almost unheard of in spite of there being on the order of 100,000 miles of electric fence in the United States alone.

The TASER CEWs satisfies the International and UL electric fence standards by a wide margin and can be thus deemed very safe.

D. Comparison to General International Safety Standards

The IEC has set 35 mA as a safe level of utility (50/60 Hz) electrical current for avoiding the risk of VF induction (electrocution).¹⁷⁰ Rapid short-pulse stimulation has the same risk of VF induction as does utility power frequencies at a current of 7.4 times higher than the average current of the rapid pulses. The *TASER X26 CEW* delivers about 19 pulses per second at a charge of about 100 μ C (microcoulombs) per pulse.³⁶ This gives an average current of 1.9 mA which corresponds to a utility power current of 14 mA = 1.9 mA • 7.4. This is seen to be less than 1/2 of the IEC VF safety level.

The *TASER X2 CEW* delivers about 19 pulses per second at a charge of about 62 μC (microcoulombs) per pulse.³⁶ This gives an average current of 1.18 mA which corresponds to a utility power current of $8.7 \text{ mA} = 1.18 \text{ mA} \cdot 7.4$. This is seen to be less than 1/4 of the IEC VF safety level. The *TASER X26* and *X2 CEWs* satisfy all relevant international electrical safety standards.¹⁰⁵

The available TASER CEWs satisfy all relevant electrical safety standards.

E. The TASER CEW Has Led to Dramatic Reductions in Injury.

Numerous published studies have now clearly demonstrated substantial injury reductions from the use of *TASER CEWs* compared to alternative control techniques.⁷⁶⁻⁸⁶

A partial list of these studies includes:

1. MacDonald which compared the CEW to pepper spray and “physical force.”⁷⁸
2. Taylor which compared the CEW to pepper spray, baton strikes, and “hands-on.”⁷⁷
3. Mesloh who studied CEW usage in comparison to many control options.⁸⁵
 - a. Gentle hold
 - b. Handcuff
 - c. Leg restraints
 - d. Pepper spray
 - e. Compliance holds
 - f. Takedown
 - g. Empty hand strike
 - h. FN303/Pepperball
 - i. Impact weapon
 - j. Canine

The largest epidemiological study was the 2009 MacDonald study of 24,380 uses of force.⁷⁸ This study found that CEW usage dramatically reduced both suspect and officer injury compared to alternative force options. Additional studies demonstrating injury reduction are memorialized in the papers of Taylor (13,983 subjects), Mesloh (n = 4303), Smith (n = 1645), Butler (n = 562), and White (n = 243).^{77,78,85,115-117}

On average, the use of the CEW reduces suspect injuries by about 2/3. To put it another way, the use of alternative control techniques triples (3x) the risk of injury to subjects. Fatal suspect shootings are also reduced by 2/3 when electronic control is used without excessive restriction.⁸⁸

- a. The deployment and use of *TASER CEWs* has been shown to reduce injuries to officers and suspects over other force options, including physical force.
- b. The deployment and use of *TASER CEWs* has been shown to reduce use-of-force citizen complaints and law enforcement internal affairs complaints against law enforcement officers.¹⁷²
- c. The deployment and use of *TASER CEWs* has resulted in the reduced need to use of deadly lethal force.

- d. Rates of injury from TASER CEWs is comparable to, or less than, some collegiate contact and exertion sports.
- e. Rates of injury from TASER CEWs is less than several other common law enforcement force options, including, but not limited to: physical force, batons, impact tools, canines, rubber bullets, and bean bags.
- f. TASER CEWs are a safer alternative than other comparable law enforcement force options tools or techniques.
- g. TASER CEWs are shown to reduce suspect injuries when compared to physical force options.
- h. TASER CEWs have greater accountability features than any other force option.
- i. TASER CEWs are the most studied force option available to law enforcement.
- j. TASER CEWs are the most effective force option in accomplishing intended effects for U.S. law enforcement.
- k. According to peer-reviewed literature, the TASER CEW causes less-severe physiologic and metabolic effects than other force options.
- l. According to peer-reviewed literature, the TASER CEW is the safest force option available to law enforcement.

The TASER CEW reduces suspect injuries and fatalities.

F. Importance of the Sound

The TASER X26 weapon is fairly quiet at 51 dBA @ 1 meter, when it is making a completed circuit connection. The X26 is significantly louder when it is *not* completing a circuit (79 dBA @ 1 m). This is like many types of equipment that are quiet when they are working properly and loud when they are not. This can be put into context with the sound levels from a sampling of ordinary sources as seen in Table 2. All examples are given with a 1-meter distance from the source to the listener except for the train whistle.

The scientific basis of the crackling sound emitted from an electrical arc has been well studied and understood.¹⁷³⁻¹⁷⁵

Table 2. Sampling of sound levels from various sources.

Sound level (dBA @ 1 m)	Source
90	Train whistle (@ 150 m)
79	X26 ECD open-circuit crackling
70	vacuum cleaner
60	polite conversational speech
51	X26 ECD closed-circuit clicking
50	average home volume, normal refrigerator
40	quiet library
30	quiet bedroom at night

There is indeed a dramatic difference between the open circuit and intact circuit sound level from an X26 electrical weapon. When the X26 is deployed with a completed intact circuit (such as contacting a body) it makes a relatively soft clicking noise which is softer than

normal conversation and on the order of the sound from a well operating refrigerator. This clicking sound is only heard in the immediate vicinity. However, in the open-circuit mode — such as when a wire is broken, a probe misses, there is a clothing disconnect, or a probe is dislodged — the sound level is 79 dBA which is well above that of a vacuum cleaner. The difference between 51 dBA and 79 dBA is logarithmic and actually corresponds to a ratio of:

$$\begin{aligned}\text{Ratio} &= 10^{((79-51)/10)} \\ &= 10^{2.8} \\ &= 631\end{aligned}$$

Thus, the X26 in arcing (open circuit, no completed circuit) mode has 631 times the sound intensity in W/m^2 (watts per meter squared). This is the same arcing sound heard when a law enforcement officer performs a spark test on the X26. With a closed circuit (good connection) the sound cannot be heard over loud conversation and generally not over yelling and shouting.

The arcing (open-circuit) sound is not only much louder but has a *different* sound. It is often described as a “crackling” sound. At a distance, the crackling sound is much softer and then it is sometimes described as a clicking.

General Comments

Previous Testimony

I have testified as an expert at trial or by deposition within the preceding 4 years in:

1. Patent case of *Philips v Zoll (Boston, MA)* (April and Dec 2013)
2. Coroner's inquest for *Firman (Barrie, Ontario)* (Jul 2013)
3. Wrongful death case of *Downen v Columbia Falls, MT* (Feb 2014)
4. Excessive force case of *Pennington v Seward, AK* (Feb 2014)
5. Criminal case of *Crown v. Eric Lim, Damian Ralph, Scott Edmondson and Daniel Barling, Sydney, Australia* (Nov 2014)
6. Excessive force case of *van Raden v Mankato, MN* (Jul 2015)
7. Excessive force case of *Brossart v Nelson County, ND* (Dec 2015)
8. Coroner's inquest in the death of *Michael Langan, Manitoba* (Jan 2016)
9. Criminal case of *Illinois v. Brad McCaslin, Rockford, IL* (May 2016)
10. Wrongful death case of *Darden v Ft. Worth. Tarrant County, TX.* (Jul 2016)
11. Criminal case of *South Carolina v Michael Slager. Charleston, SC* (Nov 2016)
12. Criminal case of *Georgia v Eberhart & Weems. Atlanta, GA* (Dec 2016)
13. Criminal case of *Texas v Murray, Angleton, TX* (Apr 2017)

Fees:

My fees for this expert witness report are \$400 per hour for the research and preparation. My fees for testimony are \$400 and are due prior to the commencement of a deposition.

Right To Amend:

The opinions in this report are living opinions. Should additional discovery material be received, or additional research be completed, and then reviewed, these opinions may be altered or reinforced depending upon what information is obtained, reviewed, or studied. If new issues are opined, identified, or developed subsequent to submission of this report, I reserve the right to supplement, or further supplement, this report. *I especially reserve the right to amend my report after receiving Plaintiff's expert reports or new forensic evidence.*

Further Development:

Further, the opinions, which are expressed in this report, are not necessarily fully developed. Rather, they are listed to comply with current report requests. Each opinion may be further developed through research, investigation, during deposition or trial testimony.

Specific References:

Some of the opinions in this report may list specific references to some of the case specific documents reviewed or considered. These listings are not intended to be all-inclusive. I

specifically reserve the right to supplement the support for each of the opinions in this report.

Opinion Methodology:

The enclosed opinions were developed using the disciplines of bioelectricity, electrophysiology, biomedical science, cardiovascular physiology, scientific methods, mathematics, and physics and are to a reasonable degree of professional, scientific, or medical certainty.

Additionally, the opinions provided in this case were developed using one or more qualitative and quantitative research methodologies, in addition to my education, training, experience, and literature review.

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